Ionizing Radiation
Dose Ranges
(Rem)

acute exposure = all at once; chronic = hours, days, years

Cancer Radiotherapy
total doses to tumor

Whole body, acute: G-I destruction; lung damage; cognitive dysfunction (death certain in 5 to 12 days)*

Whole body, acute: cerebral/ vascular breakdown (death in 0-5 days)*

6: 0 — 2000 — 4000 — 6000 — 8000 — 10,000 rem

Total Body Irradiation (TBI) Therapy

Life Span Study (A-bomb survivor epidemiology)

Acute Radiation Syndromes

Whole body, acute: circulating blood cell death; moderate G-I damage (death probable 2-3 wks)*

Whole body, acute: marked G-I and bone marrow damage (death probable in 1-2 wks)*

5: 0 — 200 — 400 — 600 — 800 — 1,000 rem

Charged particle event (Solar flare) dose on moon, no shielding

Estimated dose for 3-yr Mars mission (current shielding)

Early, transient skin erythema (2-24 hr onset)

Temporary epilation (3 wk onset)

Main erythema reaction (10 day onset)

Permanent epilation (3 wk onset)

Human LD_{50} range acute exposure no medical intervention*

Human LD_{50} range acute exposure with medical intervention

*Note: Whole body acute prognoses assume no medical intervention (G-I = gastrointestinal)

Office of Science — U.S. DEPARTMENT OF ENERGY

Cancer Epidemiology

Evidence for small increases in human cancer above 10 rem acute exposure or 20 rem chronic exposure

4: 0 — 10 — 20 — 30 — 40 — 50 — 60 — 70 — 80 — 90 — 100 rem

Typical mission doses on International Space Station (ISS)

Ramsar, Iran high natural bkg/yr

DHS emergency guideline to save a life: 25 rem

Interplanetary Space natural bkg/yr

DOE Low Dose Program

3: E F M I N J K G H L — 0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10 rem

Highest air sample .17 mrem

Kerala coast, India high natural bkg/yr

DHS emergency guideline for public relocation: 2 rem/yr (20 mSv/yr)

Guarapari, Brazil high natural bkg/yr

DOE, NRC dose limit for workers: 5 rem/yr (50 mSv/yr)

Typical added annual dose for commercial airline flight crews

Medical Diagnostics (A-O)

see chart >>

2: A B C D E F — 0 — 100 — 200 — 300 — 400 — 500 — 600 — 700 — 800 — 900 — 1,000 mrem (1 rem)

Airport x-ray whole body scanner: 0.007 mrem/scan

(Limit = 25 mrem/yr ≈ 4000 scans/yr)

Natural background, USA average ≈ 310 mrem/yr (includes radon)

Yangjiang, China high natural bkg/yr

DOE facility releases

Regulations & Guidelines

1: A B — 0 — 10 — 20 — 30 — 40 — 50 — 60 — 70 — 80 — 90 — 100 mrem

Round-trip Los Angeles – New York (≈ 3.7 mrem)

EPA dose limit public drinking water systems: 4 mrem/yr

EPA dose limit from release in air: 10 mrem/yr

NRC cleanup criteria for site decommissioning / unrestricted use: 25 mrem/yr

DOE, NRC dose limit for the public: 100 mrem/yr (1 mSv/yr) (ICRP, NCRP)

(TIPS: Transjugular Intrahepatic Porto-systemic Shunt)

Medical Diagnostics rads
(Estimated maximum organ dose)

X-ray films	
A – Chest (PA & Lat)	0.014
B – Dental Panoramic	0.07
C – Lumbar-Sacral Spine	0.2 – 0.3
D – Mammogram	0.2 – 0.4
Radiotracer Imaging	
E – Heart Stress (Tc-99m)	0.6 – 1.2
F – Bone (Tc-99m)	0.4 – 1.5
G – Dual Isotope Stress Test	4.0 – 4.5
H – PET: F-18 FDG (bladder)	5.5 – 8
CT Scans (X-ray) (multiple scan average dose)	
I – Chest	2 – 3
J – Head	3 – 5
K – Abdominal	2.2 – 6
L – Full Body	5 – 10
Fluoroscopy /Procedures	
M – Barium Contrast G.I.	1 – 2.2
N – Cardiac Catheterization	1.2 – 4
O – TIPS Procedure	40 – 140

LD_{50} = Lethal Dose to 50% (whole body dose that results in lethality to 50% of exposed individuals in 30-60 days)

Fan swap .005 mrem

Highest Dose Received 7.92 mrem

NO… simple, user-friendly, "order-of-magnitude" reference for radiation exposures of inte… most quantities are expressed as "dose equivalent" in the more commonly used radi… are expressed as estimated maximum organ dose, as they are not in "effective dose" they… limits are in effective dose, but for most radiation types and energies the difference is n… d that the decision to use these units is a simplification, and does not address everyone's needs. (NRC = Nuclear Regulatory Commission; EPA = Environmental Protection Agency; DHS = Department of Homeland Security)

Chart compiled by NF Metting, Office of Science, DOE/BER. "Orders of Magnitude" revised June 2010
http://www.lowdose.energy.gov/

Dose Equivalent: 100 rem = 1 Sievert = (absorbed dose x radiation quality)
Absorbed Dose: 100 rad = 1 Gray
1 rem ≈ 1 rad for x- and gamma-rays
(" ≈ " stands for "approximately equal to")

Source: Office of Biological and Environmental Research (BER), Office of Science, U.S. Department of Energy
http://www.science.doe.gov/ober/